

0-0026

19 Nov

Space

THE DENTIST AND THE SPACE AGE

by

William R. Stanmeyer
Captain (DC), U. S. Navy

The Dentist and the Space Age

When the atomic powered submarine became a reality several years ago, there was thrust upon the scientific world a "space ship for inner space." The true submersible and the sealed space ship have in common a condition of prolonged confinement which presents formidable problems of environmental medicine. One of the fundamental problems facing workers in both fields is the lack of knowledge concerning the extent to which man is dependent upon the natural composition of the earth's atmosphere. The submarine is affording us an excellent opportunity to solve some of these problems before putting a man into space.

The advent of the International Geophysical Year, with the decision of many nations to maintain bases in Antarctica, presented a second opportunity to study phases of environmental stresses. These stresses were related particularly to prolonged isolationism, lack of communication, changes in diurnal cycles, confinement of small groups of men for many months, food preservation and diet, in addition to severe cold.

For the past five years, dental and associated problems of the true submersible have been under study by the dental profession and, for the past three years, dentists have "wintered over" at bases in Antarctica. Information gathered from these two sources is being correlated in an over-all study called the "Effect of Stresses of an Unnatural Environment on Oral Health." It is hoped that knowledge gathered from these sources will help solve some of the problems of space travel and living.

Problems of Life in a Closed Environment

The harnessing of atomic energy and its utilization as a unit of submarine propulsion was a spectacular engineering development. The secrecy surrounding the development of the atomic bomb and the rapidity of the development of a workable atomic engine resulted in the building of a true submersible but presented problems in physiology and biology which could not be readily answered. Scientists in these fields did not know what tolerance limits or time-concentration ratios of atmospheric contaminants man could withstand.

In the closed environment of this underseas space ship, things that were never considered problems now became problems of the first magnitude. Every day household items presented atmospheric contaminants which, potentially, could reach lethal levels. Shoe polish, paint, paint thinners, mercury on mirrors and in thermometers, insect sprays, benzine in lighter fluids, acrolein from the fat in cooking, Freon from air conditioning systems and shaving soaps, smoking, with its production of carbon monoxide, and even breathing, with carbon dioxide as an excretory product, became potential sources of trouble. Still other problems that required study were the effects on the physiology of high CO_2 , low O_2 , variations in pressure, nitrogen, ozone, trace substances, heat and cold, radiation, prolonged confinement, changes in diurnal cycles and diet. In addition, there are those problems peculiar to the space vehicle itself--the gravity free state, acceleration and sensory deprivation. This, of course, is but a partial list of known sources of trouble. Every attempt is being made to anticipate further potential sources and time alone will tell how thorough is our reasoning.

Dentistry's Role in Solution of Problems

The dental profession has a dual role in the search for answers to the problems of life in an unnatural environment. It first must solve and answer those problems that are specific to the oral structures but, secondly, it can and must assist the physiologist and biologist using the oral structures as a tool for diagnosis.

In the work already accomplished in the study of the "Effect of the Stresses of an Unnatural Environment on Oral Health," a foundation has been laid, by working with submarine and Antarctic personnel, to satisfy dentistry's dual role. Work already completed can be briefly summarized.

Submarine personnel

1. Cariogenic rates.

An 18 month study was made to compare cariogenic rates of men in submarines with men living either on surface craft or ashore. The men living for the most part in a closed environment, as compared with the control group, showed almost a 100% increase in cariogenicity as determined by the DMF Index. The mean ratios showed an increased DMF (teeth) of 1.28 in the control group as compared with 2.46 in the experimental group over the 18 month period. When tooth surfaces (DMF-Surface) were compared there was an increase of 5.76 surfaces in the control group and 8.29 in the experimental group.

2. Soft tissue health.

Gingivitis as expressed by the PMA Index was also studied in these same two groups over the 18 month period. Once again the men in submarines showed an alarming increase of gingival inflammatory conditions. When the

PMA Index was used, taking into consideration only the areas involved (PMA-A) and not changes in the severity of the inflammatory conditions, the mean change in the control group was +1.36 areas; the experimental group showed an increase of +6.25 areas. If the severity of the inflammatory conditions was noted the differences between the two groups were even greater. Expressing severity as PMA-T, the control group mean increase was 2.28 while the experimental group was +7.83.

3. Atmospheric contaminants.

Oral detection of mucous membrane changes due to atmospheric contaminants is a dental responsibility. In a recent cruise of an atomic powered submarine, men began to complain of burning of the lips and oral mucous membranes. Alerting the atmospheric analysts, it was discovered that Freon had been escaping into the vessel from the air conditioning system. The amount of Freon in the air, however, was still below what was considered tolerance limits for personnel. Available literature at the time stated that the potential danger of Freon was its breakdown and formation of phosgene at high temperatures. The heat necessary for this process was attained only through such things as a welding torch which, of course, would not be used in a submerged submarine. Further research into Freon's chemistry, however, showed that at much lower temperatures (300-500° F.) Freon breaks down into the gases hydrogen fluoride and hydrogen chloride. Dissolution of these gases in the moisture of the mucous membranes produced strong acids causing mucous membrane irritation. This knowledge led to the eventual welding of all joints in air conditioning systems to prevent Freon escape.

4. Aids to physiological problems.

Dentistry has also assisted the physiologists. Through the use of the information given to us by Dr. Schour of the University of Illinois concerning the growth and calcification of the rat incisor and by the micro-calcium technics perfected by Dr. Munson of Harvard Dental School, we were able to show that carbon dioxide acts as a stimulant to the parathyroid gland. Changes were illustrated in the metabolism of serum calcium and phosphorus and histologic changes were shown to occur in the calcifying tooth structure.

In the course of these studies on calcification, an interesting observation was made on animals that had lived for varying lengths of time in an atmosphere enriched with CO₂ and then allowed to recover on room air. The recovery period was accompanied by severe reactions of accommodation as indicated by the histologic changes occurring. These disturbances appeared more severe than anything seen associated with the contaminant phase of the experiment. It has led to a new tangent of work to determine whether personnel exposed to an atmosphere containing an increased CO₂ content should be "de-gassed" in the same slow manner a diver is decompressed upon coming to the surface from the ocean depths.

Antarctic personnel

For the past three years, five dentists have "wintered over" in Antarctica. They have been collecting data not only on problems that are strictly dental but have gathered a wealth of material to assist the physician, physiologist, psychologist, bacteriologist and nutritionist. Only the first year's work

has been completely analyzed. Results of the second year's study are partially completed but information on the third year will not be returned until next spring,

1. Dental selection

The need for better methods of diagnosis of dental health prior to a prolonged isolated task was dramatically pointed out when even after careful selection prior to leaving the United States 89 of 92 men sought dental treatment during their 14 months on the ice. As the work became more tedious and the winter night progressed, as many as 51% of the men were under treatment at one time.

2. Toothaches and cold air.

Toothaches due to rapid temperature changes (+60° F. to -60° F.) were common. In most instances they were due to improperly placed fillings or improper preparation of teeth prior to arriving in Antarctica. Frequently, necks of teeth exposed by gingival recession were so sensitive to the cold that cavities were prepared and filled with an insulating cement.

3. "Dry Socket"

Alveolar osteitis was a problem. Lack of post-operative healing occurred in over 22% of extractions in the first year. During the second year of study of this problem, men were retained in sick bay and not allowed to venture into the cold for 24 hours. This reduced the incidence of alveolar osteitis to 4%. This was still considerably over the 0.9% as reported to be the national incidence by The University of Pittsburgh School of Dentistry.

Healing of other wounds was also somewhat retarded. We now believe that this high percentage of alveolar osteitis is due to basic changes in the blood clotting mechanism as a result of cold acclimatization rather than bacterial invasion. A complete hematologic study of this problem is underway at present.

4. Viral and bacterial infection.

Bacterial infections offer practically no problems. There appears to be an attenuation of bacteria due to the cold in addition to the development of an immunity to each other of the persons within the group. Colds and infections of bacterial origin become almost non-existent after 4-5 months of isolation but reoccur in most violent proportions upon the return of "outside" personnel to the isolated group.

One item of importance from the oral standpoint is that even though bacterial infections seem to cease and the virus of upper respiratory infections is inactive, oral mucous membrane ulcers occur with increasing severity as the period of isolation increases. The organism has not been isolated but the question arises as to whether there would be developed a strain of virus through inbreeding and self-inoculation more virulent than anything we now know.

5. Bacterial activity.

Cariogenic activity has not been entirely assessed. It is known, though, that when personnel are exposed to severe low temperatures the acid producing potential of oral bacteria decreases. This was determined by measuring acid production rates in dental plaques after carbohydrate rinses

when working outdoors at temperatures as low as -57° F. The numbers of oral lactobacillae also decrease during these cold work periods, probably through depression of bacterial activity and salivary dilution.

6. Vitamin tolerance.

Diet and dietary supplementation are important factors to the dentist in maintaining oral health. In submarines, Antarctica or space vehicles, food, its preservation, preparation and consumption are items of prime importance. Loss of vitamin content could cause serious general as well as dental disorders. A series of vitamin tolerance tests were performed measuring the B-complex and C vitamins to accurately determine an individual's need in terms of vitamin supplementation during long periods of isolation without fresh provisions.

7. Non-specific stresses.

Since World War II, psychosomatics in dentistry has played an ever increasing role in diagnosis. It has been suggested that various oral soft tissue lesions now occur through lowering of tissue resistance brought about by disturbances in one's equanimity. To determine what effect prolonged isolation, severe cold, six months of night followed by six months of daylight, and close habitability with the same group of men had on oral health, a "Health Questionnaire" was prepared with the cooperation of psychologists. It was completed by the men monthly as part of a routine dental examination. They were questioned in nine broad fields ranging from questions almost purely psychological to those strictly dental. Since this test was administered as an adjunct to dental treatment and since it was filled out by the men without

resistance, the opinion has been given by a prominent psychiatrist interested in problems of isolated living, that this test may result in the only valid measure from which psychological interpretations can be made over the past two years for men living in Antarctica.

Through 350,000 responses given to 68 questions on man's reaction to the stresses of prolonged confinement in an unnatural environment, where six months of darkness follows six months of light, we hope to better our knowledge of man's reaction to the total darkness of outer or inner space.

Dentistry's Continuing Contribution

Information gathered from submarines and from Antarctica is still being processed. However, problems already known must be solved. To this end, several associated experiments are underway. In an attempt to explain the increased cariogenic rates of men living in the closed environment of a submarine, the rate of caries formation is being studied using but one of the probable exciting causes at a time. Carbon dioxide, increased noise levels, loss of periods of light and dark are being studied as forerunners of cariogenic activity.

In like manner these probable exciting causes are being studied to determine what effect they have on tissue resistance and tissue repair.

The work being done in Antarctica on changes in blood both from a biochemical and cellular standpoint, should be invaluable in determining what effect living in an unnatural environment has on man.

What are Problems as Yet Unstudied

1. Selection of personnel.

Sir William Osler once said that the oral cavity was a mirror of the rest of the body. The condition of the teeth and soft tissues tells us more than the present state of a man's health. We should work closer to the psychologist in the selection of personnel for initial studies in space since, from the condition of these oral structures, we see man from six years of age to the present. Insights into the subject's tenacity of purpose, thoroughness of self-care, respect for physical fitness and probably fear of pain are all interpretations that can be extracted from a good oral examination.

2. Diagnosis.

Better methods of diagnosis of pulpal and periodontal health are also necessary. The gross methods presently used of assessing dental health are entirely inadequate for long periods of time in an enclosed environment. We must be able to more accurately diagnose sub-clinical changes in the pulp and periodontium that may cause trouble under stress. In recent studies we have discovered that such small things as changes in environmental pressure may cause acute exacerbation of conditions that could not be diagnosed under presently available methods and technics. In one instance an operating submarine had to withdraw from exercises because of a toothache resulting from a rapid change in pressure. A complete dental examination made on the subject shortly before this incident had not revealed the potential source of pathology.

3. Dental treatment.

Operative dentistry must also undergo critical analysis. Preparation of cavities must be accomplished without excess heat and vibration which might lead to pulpal destruction under increased gravitational stress. Filling material must be carefully manipulated or better ones manufactured to withstand invasion of cold, pressure changes, or traumatic stresses. What may be entirely adequate for normal living is not good enough for the Space Age.

Periodontal health must be maintained. It is entirely probable that space travel will involve capsule meals where teeth are unnecessary. Education and instruction of space personnel becomes essential to prevent periodontal or temporomandibular trouble through the atrophy of disuse.